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Conference Abstract

Understanding Intraspecific Trait Variability Using Digital Herbarium Specimen Images

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Abstract

Plant traits are vital to quantify, understand and predict plant and vegetation ecology, including responses to environmental and climate change. Leaf traits are among the best sampled, with more than 200,000 records for individual traits. Nevertheless, their coverage is still strongly limited, especially with respect to characterizing variation within species and across longer time scales. However, to date, more than 3000 herbaria worldwide have collected 390 million plant specimens, dating from the 16th century. At present, the herbarium specimens are rapidly digitized and the images are made openly available to facilitate research and biodiversity conservation.

In this study, we determined the potential of the digitized herbarium specimens images to:

1. overcome limitations of data availability for quantitative leaf traits such as the area, length, width along with petiole length and
2. use the trait values to understand the intraspecific variability across spatio-temporal scales.

For the study, initially, specimen metadata was analysed from various online resources such as the Global Plants Database, Natural History Museum Paris, iDigBio and Global Biodiversity Information Facility (GBIF). Based on the completeness of the metadata,

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image availability, and the ease of measuring the leaf traits, we selected *Salix bebbiana, Alnus incana, Viola canina, Salix glauca, Impatiens capensis, Chenopodium album*, and *Solanum dulcamara* for the study. The semi-automated tool TraitEx (Gaikwad et al. 2019) was used to measure quantitative leaf traits such as the leaf area, perimeter, width, length and petiole length.

Finally, excluding duplicates, we downloaded 17383 digital herbarium specimen images from iDigBio and GBIF, which included specimens from the 17th century to the present. However, about 5000 had insufficient information or quality issues, including not-yet-identified duplicates, or no intact leaves. For each selected image we measured four leaf traits - area, length, width and perimeter of the leaf blade - on up to 5 leaves. In sum, we collected about 120,000 trait records from 32009 leaves. Comparison of measured leaf traits to data from the TRY Plant Trait database (Kattge et al. 2019) revealed that we could improve the database for studying intraspecific trait variability by several orders of magnitude (from less than 10-100 records per species to >1000). The variation of trait records within the seven species shows reasonable patterns, which improves trust in the data quality.

The extracted trait measurements were used to analyse the intraspecific variability for the species across different spatio-temporal resolutions. Machine learning method (random forest) was used to perform the analysis and the results revealed the imprint of spatial and temporal climate variation, including long term trends and climate change as well as seasonality effects, on leaf area.

Through this study, we demonstrate the high benefits of digitizing herbarium specimens and reusing it for research studies to improve ecological knowledge and predictability of size-related leaf traits.

Keywords

morphological leaf traits, TraitEx, TRY database, iDigBio, GBIF, plant traits, spatio-temporal scales, intraspecific variability

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Author contributions

Susanne Tautenhahn is the supervisor of this project and extracted the metadata from iDigBio and GBIF. Jitendra Gaikwad provided the TraitEx tool for measuring morphological traits. Pramod Baddam helped with extracting the leaf trait information of digital herbarium specimen images using TraitEx tool. Susanne Tautenhahn and Jens Kattge supported for analysing the results of intraspecific leaf trait variability and assisted in building the methodology of the project. All authors reviewed the final manuscript.

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